

***Ochroma pyramidale* Cav. Balsa**
Bombacaceae Bombax family

John K. Francis



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Ochroma pyramidale Cav., commonly known as balsa, guano, corcho, lana, pau de balsa, and bois flot, is a widely distributed tree that invades recently disturbed land. This fast-growing species produces a very low-density wood that is used for toys, crafts, corestock, and insulation.

HABITAT

Native Range

The native range (fig. 1) of balsa extends from southern Mexico to Bolivia, eastward through most of Venezuela, and throughout the Antilles (7, 42, 48, 52, 53). The latitude extremes are 22° N to about 15° S. The species is commercially important in the Guayas River basin of Ecuador, where 95 percent of the world's harvest is taken (59). Balsa has been grown successfully in exotic settings on plantations in India, Sri Lanka, Malaya, Viet Nam, Borneo, Fiji, Solomon Islands, the Philippines, and Papua New Guinea (6, 16, 45).

Climate

Balsa requires a moist, warm climate. The minimum rainfall tolerated is about 1500 mm annually (36), except along streams where a shallow water table can be tapped by roots (58). Balsa trees occasionally grow in areas of Puerto Rico with rainfalls of up to 3000 mm annually (author, personal observation). The dry season must be shorter than 4 months (30). The mean temperature of the coldest month varies from 20 to 25 °C, and the mean temperature of the hottest month varies from 24 to 30 °C across the wide native range of balsa (56). The species is not frost resistant.

Soils and Topography

Balsa demands a rich supply of nutrients (20) and well-drained soils (29). In fact, balsa trees are reported to be easily killed by flooding (45). The species grows best in alluvial soils along rivers and this is where it is most commonly found (6). Balsa colonizes clayey, loamy, and silty soils, and even fresh road fill, but does not tolerate salty soils (6). Stands of balsa are found on both flat areas and steep slopes. In the Antilles, the species is frequently seen in valleys and

toe slope positions in humid limestone areas; it also grows on the foothills of igneous mountains (31, 32). Balsa grows from near sea level to an altitude of 1,800 m in Colombia (53) but does not grow above 1,000 m in Costa Rica (47).

Associated Forest Cover

Balsa can be found in pure stands (23, 53) or in mixed stands in association with other pioneer species such as *Cecropia* spp., *Luehea seemannii* Planch. and Triana, and *Trema micrantha* (L.) Blume (58, 59). In Ecuador, balsa is found growing with *Triplaris guayaquilensis* Wedd. and *Cordia alliodora* (Ruiz & Pav.) Oken on abandoned cropland and roadside clearings (11). Occasionally, trees may be found in mature forests (59), having successfully grown through tree-fall gaps. The species is more often found at low densities in secondary forests, such as those in Puerto Rico, with *Buchenavia capitata* (Vahl.) Eichl., *Tetragastris balsamifera* (Sw.) Kuntze, *Didymopanax morototoni* (Aubl.) Decne. & Planch., *Guarea guidonia* (L.) Sleumer, and *Ocotea* spp. (17). The Holdridge (25) life zones (tropical humid, tropical wet,



Figure 1.—Shaded area represents the native range of balsa (*Ochroma pyramidale*) in the neotropics.

John K. Francis is research forester at the Institute of Tropical Forestry, U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Río Piedras, PR 00928, in cooperation with the University of Puerto Rico, Río Piedras, PR 00928.

subtropical moist, subtropical dry, tropical wet premontane, and riparian sites in the tropical and subtropical dry forests) are all colonized with stands of balsa (52, 53).

LIFE HISTORY

Reproduction and Early Growth

Flowering and Fruiting.—The fluted, bell-shaped flowers are greenish white, about 12 cm long, and 7 to 10 cm broad; they grow as single flowers on thick peduncles near the ends of branches (31). Flowers can also be pale yellow and pale yellow tinged with red (6). Balsa is night blooming in Costa Rica, and bats pollinate the flowers, which contain nectar that has an 11 percent sugar content (3). Trees 3 to 4 years old may flower (59). Balsa generally flowers during the March dry season in Trinidad and Tobago (36) and from December to March in southern Mexico, where fruit appears from March to June (42). In western Ecuador, trees produce fruit at the end of the dry season, but in moist areas they flower and fruit throughout the year.¹ The fruit is cylindrical, dark brown, and 30 cm long by 2.5 to 4 cm thick.

Seed Production and Dissemination.—Upon maturity, the seed capsule splits into five parts, exposing a mass of white, silky fibers in which the small brown seeds are embedded.¹ An average of 950 seeds per capsule were counted from Brazilian trees (46). There are 10 to 12 g of seed in each 100 g of silk (47); 100,000 to 160,000 seeds weigh 1 kg (30, 35, 36). The silk-borne seeds are carried by the wind (47) and probably by water. In a subtropical wet forest in Puerto Rico, where rain and high humidity weigh down the silk, the seeds do not disperse much beyond the crown spread of the mother trees (12). Seeds can be collected by clipping mature capsules from low branches or felled trees, preferably in the morning when the high humidity helps prevent shattering the capsules (6). Spread in the sun or hung in a cloth sack in a dry place, the capsules will soon open and begin to release the silk-covered seeds. The seeds may be separated by hand or by burning the silk while it is spread thinly over a coarse wire screen (24). The seeds retain viability after storage for as long as 6 years in sealed containers at room temperature.² Cold storage (4 °C) is advisable, however.

Seedling Development.—Without adequate warmth, moisture, and sunlight, seeds can lie dormant for several years on the forest floor. When conditions are right, germination begins in about 5 or 6 days and can vary from a few percent to more than 90 percent (6, 36). Several treatments are reported to increase germination; a hot water soak for 20 minutes (15), a boiling water soak for 2 to 3 minutes (6), a soak in coconut water for 12 hours (49), scarification (51), and fire (24). Boiling for 15 seconds or exposure to dry heat

(96 °C) for 5 minutes was found to work the best (51). Alternating temperature regimes (20 hours at 25 °C followed by 4 hours at 45 °C) improved germination, but light had no effect. Germination is epigeous (43).

In the nursery, seeds are sown in germination trays filled with potting mix and lightly covered with sand (57). When they reach about 5 cm in height the fragile seedlings are carefully transplanted into nursery bags. Great care must be taken during this operation, as the seedlings are easily injured. Seedlings begin growth in shade and are gradually moved into full sun. After about 4 months, seedlings are large enough (20 cm tall) to outplant (30, 57). Containerized stock must be used because seedlings do not survive bare-root transplanting (30) and do not tolerate root pruning (17). Slightly better growth was obtained by seeding directly into nursery bags to avoid transplanting from germination trays (46). Direct seeding, a few seeds per tilled seedspot, which are then lightly covered with soil, is an alternative method.¹ A 0.5 kg of seeds is sufficient to sow 2 ha of seedspots at a 3-by-3-m spacing. Each seedspot must be thinned to one seedling within 3 or 4 months. Initial spacing in plantations where early, heavy thinning is planned should be about 2.1 by 2.1 m (57), or 5 by 5 m where thinning is to be delayed or crops are to be planted between rows of trees (17). First-year survival rates of 81 and 96 percent were reported for two plantings in Brazil (46).

Natural stands require thinning to attain the desired rapid growth because balsa often has extremely dense regeneration (58). The following per hectare thinning schedule, which was originally applied to plantations, is suggested: 3 or 4 months, thin to about 2,000 seedlings; 1.5 years, thin to 1,500 saplings; 2.5 years, thin to about 750 trees; 3.5 years, thin to about 100 trees; 5 years, clearcut (16). Unfortunately, there is no commercial use for small diameter material cut in early thinnings. Former balsa stands that were burned or heavily disturbed during harvest, and sites on suitable soils near seed-bearing trees, will normally regenerate to balsa or a mixture of pioneer trees including balsa.

Vegetative Reproduction.—There is no vegetative reproduction in this species (58).

Sapling and Pole Stage to Maturity

Growth and Yield.—Balsa trees grow extremely fast. Seedlings will reach heights of 1.8 to 4.5 m by the end of the first season and 11 m by the end of the second (58). The ultimate height may be 25 to 30 m or more (28, 42, 58). A vigorous tree may reach a diameter at breast height (d.b.h.) of 40 cm in 5 or 6 years (26); occasionally trees attain a 100-cm d.b.h. at a more advanced age (59). Due to the unusually fast growth rate, balsa has the capacity to concentrate most of the energy allocated to wood production into the stem by producing few branches and large simple leaves with branchlike petioles (21). Branching follows the Koriba model, in which initially equal shoots develop at each node, then one shoot assumes dominance and takes an erect posture to become the leader. Balsa produces three axes at each node, one for the leader and two for branches (22).

Balsa matures economically and physically at an early age. Fast-growing trees give the best yield and best product when 5 to 6 years old. Trees 7 or 8 years old begin to develop a water-soaked heartwood called water heart (58). After 12

¹ Unpublished manuscript by Brown, Delmar. 1989. Notas sobre dieciseis especies de arboles maderables tropicales de Ecuador. Colorado State University, Fort Collins, CO. 51 p. On file at the Institute of Tropical Forestry, Río Piedras, PR.

² Marrero, José. 1949. Final report 775. On file at the Institute of Tropical Forestry, Río Piedras, Puerto Rico.

to 15 years, trees deteriorate rapidly (33), and few survive longer than 20 to 30 years (26). Volume production potential for balsa at harvestable age in pure stands is 17 to 30 m³/ha/yr (56). Stands in an evergreen broadleaf forest in Ecuador's Guayas River basin, of which balsa is a component, contained from 125 to 200 m³ of standing volume (11). Experimental plantations in Malaya have grown somewhat slowly (10 m³/ha/yr or less) and resulted in wood somewhat heavier than desired (62). Varying degrees of success and failure with plantations are reported from tropical areas around the world (45).

An equation for predicting total aboveground volume for tropical timber trees was developed using linear regression techniques (10). Volume (V) in m³ is given by $V = 0.368 + 0.545 GH$, where G is basal area in square meters and H is total height in meters. Four of the 30 trees used to develop the equation were balsa.

Rooting Habit.—Young balsa trees are supported by a shallow root system. At about 7 years, trees develop a taproot, which causes the wood in the center of the tree to become supersaturated with water.³ Large trees often have moderate buttressing.

Reaction to Competition.—Balsa has all the characteristics of a pioneer species. It is very intolerant of shade, grows rapidly, produces soft wood, and is short lived (22). New seedlings will etiolate if placed in shade (2) and require large gaps in the forest in order to grow well. Increased soil temperature caused by direct sun seems to be required for seeds to germinate. New alluvium, landslides, road fill (fig. 2), abandoned fields, heavily burned areas, clearcuts, and treefall gaps are frequently colonized sites (6, 23).¹ Unless sites with balsa stands are disturbed, the balsa will be replaced in the second generation by more shade tolerant species.

Plantation stand density greatly influences diameter growth rate but does not appear to reduce total height growth or height to the first branch (62). An initial spacing of 4.3 by 4.3 m in a Malayan planting resulted in densities (about 6 m²/ha) during the first or second year that began to retard diameter growth.

Unit leaf rate (dry weight increase/m² of leaf area/week) is a measure of growth efficiency. The rate for balsa was not significantly different from the rate for sunflower (*Helianthus annuus* L.), a benchmark species, and was higher than rates for a number of tropical tree species tested (40, 60).

Damaging Agents.—A shoot boring Lepidoptera, *Anadasus porinodes* (Meyrick), that is found through most of the continental range of balsa, can devastate plantations (5). Isolated trees often escape attack.

Tropical ants (*Paraponera* sp. and others) feed on lines of red sap-filled tissue beneath the petioles and along leaf veins (extrafloral nectaries) of balsa. The ants react aggressively when disturbed and provide protection for the plant.



Figure 2.—Seedlings of balsa (*Ochroma pyramidale*) growing on new calcareous road fill.

When ants are absent, there is an increase in leaf damage by herbivores (41, 63).

Many organisms feed on the wood of balsa. In Puerto Rico, a wet-wood termite, *Nasutitermes costalis* (Holmgren), consumes dead limbs and fallen wood (37). Balsa is listed as very susceptible to attack by a dry-wood termite, *Cryptotermes brevis* (Walker) (61). In one study, dry-wood termites consumed balsa in preference to *Thuja plicata* Donn, *Pseudotsuga menziesii* Franco, and *Pinus* spp., and nymphs developed faster on balsa than on the other species (13). Balsa is severely attacked by marine borers, and logs and green lumber can be severely damaged by pinhole borers if the wood is not processed quickly (33). The wood is also listed as being susceptible to *Lyctus* spp. (powderpost beetle) damage (18).

The limbs of balsa trees will break in high winds (55). Usually the leaves are stripped off before the trunk snaps or uprooting occurs (author, personal observation). Unfortunately, fungi enter the broken branches and cause rot and disease (45). Care must also be taken not to injure or cut into the trunks of young trees because pathogens enter through such wounds (47). In the seedling stage, balsa is very susceptible to attack by damping off fungi (17). Balsa wood will rot rapidly in contact with moist soil and will stain if not sawn and dried soon after harvest (27).

SPECIAL USES

Balsa heartwood is pale brown or reddish brown, and the sapwood, which comprises most of the commercial timber produced, is white to pale tan (9). Balsa wood is medium to coarse textured, lustrous, straight grained, and without annual rings. It is the lightest commercial wood in use in the world today (33). A few other species produce lighter wood, but they lack suitable strength.¹ Commercial balsa wood usually ranges in density from 0.10 to 0.17 g/cm³ (9), but can vary from 0.05 to 0.41 g/cm³. Because trees grow more slowly as they age, density increases linearly with distance

³ Unpublished manuscript by Delmar Brown. 1989. Arboles de Ecuador 1/Trees of Ecuador 1. Colorado State University, Fort Collins. 51 p. On file at the Institute of Tropical Forestry, Rio Piedras, Puerto Rico.

from the pith and with height above ground (58). Other factors associated with a high wood density are large tree size, presence of water heart, dry climate or microsite, and slow growth. Balsa wood with varying densities had a modulus of rupture of 148 to 372 kg/cm², a modulus of elasticity of 30,000 to 62,000 kg/cm², and maximum crushing strengths of 63 to 64 kg/cm² (15). These values are very low compared with those for conifers and lightweight hardwoods (4) but are equitable when differences in specific gravity are taken into account. Balsa wood dries quickly with little degrade. Kiln drying, particularly with thicker stock, yields a much better product than air drying (4). Shrinkage while drying from green to 12-percent moisture is 1.6 percent radial and 4 percent tangential (54). Balsa wood is 92 percent air space and has a very low thermal conductivity (4, 54).

Balsa wood has a relatively low lignin content (26.5 percent) and an unusually high ash content (2.12 percent) (34). Little of the ash seems to be silica, as the wood does not quickly dull cutting tools (33). Balsa cuts and planes easily with thin, sharp cutting tools but becomes wooly or crumbly if the tools are thick or dull (33). For lack of sufficient strength, balsa wood does not hold nails or screws well. The wood glues well, and gluing is usually the most efficient method of fastening balsa. It sands easily and can be stained and varnished satisfactorily, although it is very absorbent (14).

Balsa logs were used for centuries to make rafts; the name balsa actually means raft in Spanish (58). Today, the wood is used for models, crafts, and toys, as corestock in sandwich construction with synthetics, aluminum, and wood where strength and insulation are needed. It is also used for massive, static-free insulation for cryogenic transport ships (1, 9, 39, 54).

Although short-fibered like most other hardwoods, balsa wood has been used to a limited extent for pulp and paper making (26, 54, 56). In many of its traditional uses, such as fishing floats and life rafts, balsa is being replaced by styrofoam and other synthetics. Certainly much change and adaptation will be necessary to maintain demand for this product. Perhaps the fact that it is a nonpolluting, organic material may help preserve the demand in years ahead.

Balsa is sometimes grown as an ornamental because of its large leaves and flowers (32). The seed cotton is used as a substitute for kapok for stuffing and padding, being preferred locally to the kapok derived from *Ceiba* spp. (8). Balsa is frequently used as an index species for investigations of the physical properties of wood and susceptibility to rot and insects (19, 38, 44, 50).

GENETICS

Although its wide distribution and some variation led botanists to propose several species and varieties of *Ochroma*, the genus is now considered to be monotypic (58). Botanical synonyms for *Ochroma pyramidale* are: *O. lagopus* Sw., *O. lagopus* var. *occigranatensis* Cuatr., *O. obtusa* Rawl., *O. tomentosa* Willd., *O. bicolor* Rowlee, *O. boliviana* Rowlee, *O. grandiflora* Rowlee, *O. lagopus* var. *bicolor* (Rowlee) Standl. et Steyer., *O. limonensis* Rowlee, *O. peruviana* Sohnt., *O. velutina* Rowlee (32, 53).

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